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The Role of Context in Behavioral Effects of Foods

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INTRODUCTION

The situation in which we eat, the eating context, is receiving increasing attention as a major factor in the control of eating habits. Traditionally, more attention was placed on the food itself and the personality characteristics and physiology of the eater. Placing food in its context has led to research and discussion of a number of situational or contextual variables such as the effort needed to obtain food (Collier, 1989; Meiselman et al., 1988), the time of day food is eaten (Birch et al., 1984; Kramer et al., 1992), the presence of other food, and social dynamics (de Castro and Brewer, 1991). Schutz (1988) sought to capture the overall impact of eating contexts in his measurement of "appropriateness," which indicates how well a food fits into a particular situation.

The emerging role of context has been reflected in its inclusion in recent international meetings. At the First International Conference on Food Choice,

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a multidisciplinary meeting held in Brussels, Belgium, in July 1992, a number of sessions were devoted to the cultural and social context of eating, and papers throughout the meeting addressed context as well. At the meeting on Advances in Sensory Science, held in Helsinki, Finland, in August 1992 in memory of Professor Rose Marie Pangborn, an entire session was devoted to context.

The U.S. Army's interest in context began with large field studies of the military ration, the Meal Ready to Eat, in the early 1980s. The traditional approach was to research and evaluate food product development and improvement. In the early 1980s, however, researchers began to realize that without attention to the eating situation they could never fully understand what controls eating and what should be done to maximize soldiers' intakes of needed nutrients. Some of that research is presented in articles by Meiselman et al. (1988) and Hirsch and Kramer (1993).

Not only was it necessary to rethink what controls eating, but it was also necessary to rethink how to conduct research. Researchers began to doubt the adequacy of short-term laboratory tests, and so they focused more on longer-term field tests that better covered the situational variables that are now viewed as critical. The questioning of how human food research is conducted led to a recent critical review of methodology in the journal *Appetite* (Meiselman, 1992).

The role of context has long been realized in the experimental design literature (Campbell and Stanley, 1966). The difference now may be that while context was traditionally seen as a source of confounding to be controlled, more effort is currently being put into defining and studying the impact of context. The change in research is not only in how research is conducted but also in the focus.

A useful example might be derived from the growing body of research on noncaloric substances such as sugar and fat substitutes as human foods. The initial studies were simple, looking at the impact of a sweet drink (e.g., aspartame-containing beverages) on the subsequent intake of a test meal. In principle, to the subjects the drinks or other vehicles were made to seem equivalent, so that any differences in response to the drinks could be attributed to the fact that one contained calories and the other did not. Among these early studies of aspartame were reports (Blundell and Hill, 1986) suggesting that consumption of such items enhanced hunger and possibly intake as well, implying that diet drinks would not only fail to produce useful reductions in caloric intake but might actually be associated with increases. Early studies also indicated that typical two-group comparisons could not readily separate out the role of calories versus the role of sweetness (Blundell et al., 1988). Given the nature of these findings, aspartame and other noncaloric sweeteners have been the subject of many recent studies (see Rolls [1991] for a review), but those studies have not yet clarified their impacts on food habits. What those studies have made clear is that the results and conclusions reflect the context of the study. Depending on the investigation, aspartame is associated with an increase, decrease, or no change in eating or other outcome measures (Rolls, 1991). The context of the studies has varied across the means of administration (flavored or unflavored beverages, food and meal ingredients, chewing gum, capsule form), timing of administration (preload before a measurement period, during a meal or meals, at multiple times during the day), outcome measures (consumption, palatability, hunger or other subjective ratings, thermic effect of ingestion), length of study (single meals, 24-h impact, 1 to 2 weeks), and participant expectations (whether subjects were informed that they were taking aspartame, use of aspartame as a diet aid).

The role of context in studying the effects of foods on performance and mood and then applying those effects covers a wide area. One could discuss the context of the research situation, its physical and social environment, and the food and its immediate context. One could discuss the nonresearch eating situation in which, ultimately, foods of interest are consumed. One could also discuss the military context, which investigators are trying to address using performance- and mood-altering foods. Not all aspects of the topic can be covered because of the current state of the art, but this chapter should remind the reader of context and perhaps raise the reader's assessment of its role in the effects of food on performance and mood. Context can be covered by looking at foods, the people who eat them, and the environment in which researchers test and try to predict peoples responses.

DETERMINING A BASELINE

Studies of the effects of foods on performance or mood generally need a baseline condition against which treatment effects can be measured. Kruesi and Rapaport (1986) point out that baseline data can be used to estimate variance and help to control problems of individual differences, a key problem in these tests. However, Kruesi and Rapaport also note the potential problems of treatment order effects whenever a baseline precedes a treatment.

Christensen (1991) discussed several alternatives for controlling the immediate previous nutritional states of test subjects. For a diet that is to be consumed the next day, for example, the experimenter can request abstinence from eating following the evening meal or can administer a standard meal before the test. Both conditions might require that subjects receive instructions about what else they can or cannot eat or drink. The subjects' "normal" eating is being changed, which sets up potential changes in, for example, eating habit patterns and concern about what is being done to them.

In some cases, Christensen (1991) recommends an elimination or washout phase for 2 to 3 weeks, such as those used in allergy research. They point out that the elimination phase allows for baseline assessment of behavior and permits the full range of the response to manifest itself after reintroduction of the food. A washout phase can clearly show the benefits of avoiding the food and the detriments or advantages of adding the food to the diet. However, this method or approach is likely to influence subjects' expectations. Washout phases must be done with the subjects' permission and cooperation. The subjects must think, for example, that they are doing something to help themselves, something aversive, or something difficult. A washout condition is not like a neutral baseline where one measures "normal" behavior before the introduction of the treatments. The washout condition is a treatment itself that can produce, for instance, withdrawal effects (for caffeine, see Griffiths and Woodson [1988]), varying widely in incidence, severity, and duration. Therefore, subjects must be warned of potential adverse effects, perhaps exacerbates their expectancies. Christensen and colleagues (1991) further point out that the treatment does not always result in prewashout levels.

In addition to attending to dietary baselines, one must also consider the subjects' overall baseline condition. Their prior psychological state could be significant if mood changes are a possible or likely outcome of the dietary treatment. Psychological state could also affect performance on some tasks (e.g., demanding cognitive tasks).

Researchers need to decide whether to consider baseline behavior and mood under conditions of nutrition similar to those that occur in field or nonfield situations. It has been well documented that soldiers in the field, on average, do not eat all of their food. Many eat so little that they lose weight. This issue of underconsumption is dealt with below; the issue here is to highlight the problem of specifying the nutrient status under which the baseline is determined.

Thus, before one even begins a test with a food stimulus, there is a context problem. In what way does one determine baseline performance, and in what way does one examine behavior or mood without any treatment? Many ways of establishing baselines might be as potent as treatments in changing food habits.

EXPECTANCY

Studies in both humans and animals have repeatedly shown that subjects' expectancies and attributions regarding an "intervention" can dramatically change cognitive, emotional, and behavioral responses. Placebo effects are of critical importance in drug-behavior research. The risk of such attitudinal effects has led investigators to use, for example, double-blind crossover designs with or without washout phases to be able to conclude that any effects that they find are due to the drug or nutrient under study.

Although studies designed to control for the cognitive effects of expectancies, for example, are an important and necessary step in the evaluation of potential performance-enhancing substances for the practitioner or, for the purpose of this volume, the U.S. military, the issue is whether these interventions will be potent in both the expected and unexpected real-life scenarios soldiers face. One cannot approach these questions from a purely physiological point of view. For instance, Siegel (1988) in rat models and Marlatt and Rohsenow (1980) in a study of humans have shown that in situations in which pharmacologically active doses of potent, addictive drugs are administered with the organism either expecting or not expecting the substance, the consequences of ingestion are determined more by the organism's expectancy than by whether or not the substance is consumed.

Caffeine is a good example because it is commonly used in an effort to maintain alertness and performance by both civilian and military personnel. Caffeine has been shown to be effective at maintaining alertness and to function as a potent reinforcer (Griffiths and Woodson, 1988). A recent double-blind trial found that withdrawal symptoms can occur in chronic caffeine users even when that use is modest (i.e., about 0.59 l [2.5 cups] of coffee per day). These findings indicate the potency of caffeine. Nonetheless, studies of caffeine (Fillmore and Vogel-Sprott, 1992; Kirsch and Weixel, 1988) have found clear effects of expectancies on measures as diverse as mood, blood pressure, and motor performance. Parallel studies on placebos, alcohol, and eating likewise indicate that expectancies improve behavioral outcomes (Lick and Bootzin, 1975; Marlatt and Rohsenow, 1980; Polivy, 1976).

Given the potential importance of these cognitive mediators, research is needed not just on controlling them to determine the utility of various substances but also on understanding and applying these influences in relevant situations. For example, Cardello and Sawyer (1992) have shown that one's expectation of a food determines its acceptability and is related to how much is consumed. A number of studies have shown that military food and food in a military package are perceived unfavorably, which may explain, in part, the typical underconsumption of rations by soldiers. Studies of expectancies and attributions would help not only in determining the ultimate usefulness of agents but also in developing guidelines for administering the substances (e.g., nutrient supplements within food items versus in pill form) and educating soldiers to obtain the best match of cognitive and physiological forces.

CONTROLLING THE FOOD, STIMULUS, AND TREATMENT

A number of reviews have highlighted the need for carefully controlled treatment conditions. Kruesi and Rapaport (1986) call for double-blind treatment conditions in which neither the subject nor the experimenter can identify treatment conditions. Blind conditions are essential when the subject or experimenter is likely to have beliefs or expectations about the treatment in particular or the behavioral effects of foods in general. Christensen (1991) even suggests that expectancy can produce behavior that mimics treatment effects under the placebo condition and that one must use continuation of an effect to determine a real treatment effect. Many people claim sensitivity to monosodium glutamate, but very few people actually show an allergic reaction under blind conditions (Meiselman, 1987).

To utilize blind conditions, there must be a treatment substitute (placebo) that is indistinguishable from the treatment. Substituting decaffeinated coffee for caffeinated coffee, for example, appears possible in the short term; but making large dietary changes, like substituting aspartame for sugar in all foods and over an extended period of time, is often not possible (Christensen 1991).

Neither the treatment nor the placebo condition should require the subject to expend more effort. Studies have shown that increased effort affects food choices and intake in both laboratory and natural eating environments (Engell and Hirsch, 1991; Meiselman, et al., 1994). When the effort to obtain a food is increased, selection and, as a result, intake of that food decrease. Moreover, the depressed intake does not necessarily appear to recover quickly or fully when the need for increased effort to obtain a food is removed.

Controlling the treatment often requires placement of the treatment at a certain frequency within the 24-h cycle. The experimenter must decide how often and at what times to deliver the treatment. These times and cycles might not coincide with the subject's normal daily patterns of eating or activity. The issue is whether to allow the subject to control the timing of treatment, or permit the experimenter to test all subjects at the same treatment time.

PEOPLE

Individual Differences

It is a truism to say that the effects of a given nutrient or other form of intervention vary from person to person. In broad terms, individual differences in response can be either continuum based (i.e., the dose-response relationship varies across individuals) or category based (i.e., a subset of individuals does not respond to the intervention or some individuals might respond in a paradoxical manner). One needs to determine not only the average response but also who responds and to what degree, and one must attempt to determine whether the differences between people are due to their intrinsic characteristics or to other outside influences. In part, this speaks to determining the dosage method that best captures the population of interest. Another assumption that may need to be addressed is person-situation consistency. In other words, if one can reliably describe how a given set of people will respond to the intervention in a particular situation, can one generalize across situations; or is it the case that exposure to physical or psychological stress will change who does and who does not respond? The ultimate goal is to derive a situation- and person-specific dosing system.

Individual differences also can play a mediating role. For example, caffeine may function fairly successfully as an alertness enhancer in most people, or tyrosine might aid in the reduction of stress-based decrements in performance. However, as noted previously, if the relevant source items are not consumed—a real risk with military rations—then the effectiveness or lack thereof is moot. A well-known fact in dietetic studies is that intraindividual variation for most nutrients is as large or larger than interindividual variation (Beaton et al., 1979). Thus, if the agent of interest has a relatively narrow range of effectiveness or is otherwise inflexible regarding its daily required dose, a substantial chance of ineffectiveness arises solely because of soldiers' inconsistencies in consuming source rations or items.

Also of relevance here is that to determine the true daily intake of nutrients in the face of large intraindividual variations, repeated assessment of intake over a number of representative days is required (about 7–14 days depending on the nutrient of interest) (Basiotis et al., 1987; Beaton et al., 1979; Nelson et al., 1989). Similarly, inter- and intravariations in subjects' responses to nutrients could be determined and used to guide the length of evaluations as well as to help investigators understand better the individual variation. Beaton and colleagues (Beaton et al., 1979; Tarasuk and Beaton, 1992a,b) discuss at length the nature and implications of within-subject variability in nutrient intake. A study by Caputo and Mattes (1992) is typical. Subjects were overfed or underfed with carbohydrate or fat. The authors concluded that, although as a group, subjects compensated better for dilutions than for supplementations of energy intake, individual patterns of compensations were highly variable. Likewise, Epstein (1980, 1983) has championed this focus on extended assessment over time as the best approach to obtaining stable behavioral measures. In general, studies on the role of nutrition on behavior might have to be longer than is currently the norm.

Clinical Disorders

One aspect of individual differences may be represented by individuals with clinical deficiencies or excesses. For example, food and mood (Herman et al., 1987; Leathwood and Pollet, 1982-1983; Morley et al., 1986) are frequently linked, as are mood and performance. Both anxiety and depression have been linked to changes in behavioral activation and food intake. Although the "typical" response to such negative moods—especially at high levels—is a decrement in food intake as well as performance, there are subgroups that tend to show enhanced eating in the face of such stressors. Although clinical disorders per se may not be of central importance to examining the nutrition-performance relationship in the military, such studies do provide a basis for examining the potential role of underlying physiological or psychological states on the relationship.

For example, although both fear and hunger alone can potentiate behavior, when both are present the combination of an aversive and appetitive stimulus can lead to different experimental conclusions, depending on the assessment methodology. As reported by Gray (1987), fear reduces the probability of eating in a hungry subject, but if eating does occur it is more vigorous than that in a nonfearful subject. It is not unreasonable to expect that different mood states will influence the probability of behavioral choices and, in turn, also influence the strength of that behavior once it is chosen.

A more apt example of pathology relates to the impact of jet lag or shift work on performance. This topic has received considerable attention from U.S. Army Research Institute of Environmental Medicine (USARIEM) as well as many other military and civilian research centers (Moline et al., 1990; Tepas, 1990). Circadian rhythms appear to be intimately linked to metabolism, mood, and behavior, and as has been shown repeatedly, disruptions of these rhythms are also disruptive to performance (Armstrong, 1980; Boulos and Terman, 1980; Halberg, 1989). Given the nature of military operations, challenges to circadian rhythms are to be expected, and in instances of rapid deployment, they pose a potentially serious risk. Circadian rhythms may also have a mediating role on food and performance relationships (Mistlberger, 1990). Metabolic research suggests that physiological responses to nutrients vary depending on the time of day when the nutrients are ingested. In addition, the timing of a meal appears to influence some, although not all, biological rhythms. The appropriate type of dietary component and the appropriate dose and schedule of ingestion depend, among other factors, on the schedule in force prior to the disruption, the specifics of the actual disruption, and the feeding and sleep schedule that is possible following the disruption.

Social Influence

Although social sources of influence are pervasive, much remains to be learned about how social factors influence performance and behavior. Social influences are difficult to assess, in part because such influences can be manifested in several ways. Social influences may be categorized in terms of time of occurrence (e.g., influences that occur at the time of measurement versus influences that reflect past experience) and by pathway (e.g., behavioral or verbal modeling and social context) and whether the influences have a direct or indirect impact on what is being measured. Social influences can enhance or detract from concurrent physiological factors (Goldman et al., 1991). Furthermore, social influences can be evaluated in terms of individuals or groups. The majority of food intake research focuses on individuals, as in studies of how much a subject consumes when a confederate eats a relatively large or small meal. The military, however, has a long-standing interest in issues such as unit morale and cohesion and how these group-oriented variables affect unit performance.

A growing body of work (de Castro and Brewer, 1991; Redd and de Castro, 1992) indicates that consumption increases for individuals as the number of people with whom they are eating increases. This social facilitation has been seen with other behaviors (Latane, 1981). The findings of de Castro and colleagues appear to be at least partially explained by the fact that meal length increases as well, while the rate of eating remains nearly the same. However, the data to date do not clearly indicate that increased meal length is the sole determinant of this social facilitation of eating.

Studies have also found that the behaviors or actions of others (e.g., a sergeant and the soldiers under his or her command) can have substantial direct effects on consumption and acceptability. For example, research at Fort Devens found that soldiers ate significantly more rations at a meal and rated foods as more acceptable when their sergeant made a moderate positive comment and ate most of their meal than when he made a moderate negative comment and ate approximately two-thirds of his meal (Engell et al., 1990). Similarly, following a 2-week ration field test, soldiers who reported that they typically ate their meals in a social setting (i.e., with a small group of friends or colleagues) consumed approximately 5 percent more calories than soldiers who reported that they typically ate either alone or in the midst of a large, undifferentiated group of fellow soldiers (F. M. Kramer, U.S. Army Natick, unpublished data, 1991).

Studies with military and civilian personnel have also shown that social influences such as modeling and persuasion can influence attitudes and behaviors toward food (Edelman et al., 1986; Polivy et al., 1979; Smith, 1961). An interesting aspect of that research was that changes in behavior (e.g., consumption) and attitudes (e.g., hedonic ratings) were not always consistent with one another (Meiselman et al., 1988). For example, Smith (1961) found that after an experienced U.S. Army sergeant explained to his men the importance of eating unusual foods such as grasshoppers in order to survive and concluded his talk by actually eating a grasshopper, 90 percent of subjects ate one or more grasshoppers; in contrast, hedonic ratings gave no indication of an attitude change. On the other hand, following a cognitive dissonance approach, after soldiers heard a talk by an aloof professional who offered 50 cents to each person who would eat a grasshopper, only 50 percent of subjects actually chose to do so, although hedonic ratings indicated a significant, positive change in attitude. As in other types of research, different measurement methods or different aspects of a phenomenon may yield varying results and conclusions. To be sure of their findings, investigators need to be cognizant of a multitrait-multimethod approach (Campbell and Fiske, 1959).

CHEMICALS, FOODS, AND MEALS

In a number of human eating research areas, the relevance of stimuli has been discussed (Meiselman, 1992; Spitzer and Rodin, 1981). Studies of nutrition and behavior probably run the range from pure chemical stimuli to entire complex, long-term diets. Different levels of treatment complexity are listed in Table 8-1. Each level of complexity brings with it a set of advantages and a set of disadvantages. Moreover, within each level there can be further distinctions; pure chemical substances can be given in subphysiological doses, physiological doses, or superphysiological doses. Complex meals can be three or more components all on one plate, or they can be multiple courses. Complex diets can involve three meals per day, or they can involve ad libitum consumption of a wide range of foods.

Within the wide range of possible stimuli in food behavior studies, many variables influence food intake habits. For example, Engell (1992) has recently shown that in a meal setting, increased beverage variety leads to increased beverage consumption and increased food consumption. How one constructs laboratory meals and diets in many ways determines the outcomes of studies.

Ultimately, researchers need to know what to serve as an entire diet since that is what all people eat. Although pure substances and simple foods and meals might need to be researched to get the building blocks for diets, can one safely assume that the effects seen in isolation will remain when added to the overall diet? Or, conversely, will dietary components, produce behavioral or mood effects only when added to other dietary components, as Kruesi and Rapaport (1986) suggest?

TABLE 8-1 Levels of Treatment Complexity

Treatment Category	Examples
Pure substances	Subphysiological dosage Physiological dosage (Griffiths and Woodson, 1988) Greater than physiological dosage--better enhancement of behavioral effect (Spring et al., 1986)
Simple foods	Pure protein (turkey salad) or pure carbohydrate (bread-like wheat starch) (Spring et al., 1986) Breakfast drink or no food for breakfast (Benton and Sargent, 1992)
Complex foods	Ham casserole as a meal (van Amelsvoort and Weststrate, 1992)
Simple meals	Different breads with cheese, margarine, and coffee or tea (Holm and Bjorck, 1992)
Complex meals	Buffet lunch on 3 alternate days with preload and taste trays (Rolls et al., 1992)
Simple diets	Liquid diet for space travel, 19 weeks, prisoners (Winitz et al., 1965) Two basic meals high and low in energy for 5 days (Caputo and Mattes, 1992)
Complex diets	21-day diet (oat bran, wheat bran intake) in metabolic ward (Anderson et al., 1991) Vending machine diet of entrees, desserts, snacks, and beverages for 7 days (Rising et al., 1992)

All investigators should be clear about the current situation and the challenge ahead. The written military requirement for performance-enhancing ration components (dated July 30, 1992) states that the performance enhancing rations "would be sufficiently stable to withstand long-term storage; they would be sufficiently appealing to ensure consumption; and they would be packaged to withstand standard ration abuses and to promote ration acceptance." This requirement expects more from a performance-enhancing ration than was obtained from the current ration, the Meal Ready to Eat (MRE) (Hirsch and Kramer, 1993; Lester et al., in press; Meiselman et al., 1988). At present, the long-term storage requirements for rations lead to difficult demands for both the developer and the consumer, but these are outside the topic of this chapter. However, although the Army provides the soldier 3,900 kcal/day for moderate activity in a temperate climate, at present a soldier eats well under 3,000 kcal/day on average and occasionally eats under 2,000 kcal/day, on average.

Many data have been collected from both short-term (Table 8-2) and long-term (Table 8-3) studies of acceptance and consumption of the MREs. Although earlier studies suggested a gradual increase in MRE consumption, this trend has not continued. It is clear that MRE consumption is far more complicated than simply how acceptable the foods are rated.

Since the goal is to enhance performance in combat, one must also question whether a soldier in actual combat would eat more or less than what field training exercise studies have shown. Questionnaire data collected from U.S. Marines who had been in combat indicated that they ate as little as 58 per-

TABLE 8-2 Prototype Testing (Short-Term Study) of Meal Ready to Eat Rations

Reference	Specific Ration*	Test Duration (days)[†]	Intake (kcal/day)	Acceptance Overall	Acceptance Main Dish
Askew et al. (1987)	MRE IV	12 (3 MREs/day)	2,282		NA[b]
Popper et al. (1987)	MRE IV	11 (3 MREs/day)	2,517		5.7
	MRE VII		2,517		6.8
	IMP MRE		2,842	7.86	7.6
Engell et al. (1987)	MRE V	10 (4 MREs/day)	2,733		6.2
Morgan et al. (1988)	MRE VIII	11 (4 MREs/day)	3,217		
Lester et. al. (1990)	MRE VIII	3 (4 MREs/day)	2,550		7.03
			2,289		7.39
			2,206		6.56
Edwards et al. (1989)	MRE VI	10 (4 MREs/day)	2,009		6.34
	MRE VIII		2,802		7.33
Lester et al. (1993)	MRE VIII	7 (3 MREs/day)	1,956	5.6	6.8

* Starting in 1980 the Roman numeral indicates the year of production; for example, MRE IV was produced in 1984.
† NA= not available.
‡ IMP MRE was improved MRE.

TABLE 8-3 Extended Testing of Meal Ready to Eat Rations

Reference	Specific Ration*	Test Duration (days)	Intake (kcal/day)	Acceptance	
				Overall	Main Dish
Hirsh et al. (1985)	MRE IV	34	2,189	7.05	7.05
Hirsch and Kramer (1993)†	MRE IV	45	3,149	6.05	
Askew et al.	MRE VI	30	2,782	6.53‡	6.99
Thomas et al.§	MRE XII	30	2,441		

* Starting in 1980 the Roman numeral indicates the year of production; for example, MRE IV was produced in 1984.
† Student volunteers.
‡ Final questionnaire.
§ Technical Report in preparation.

cent of their normal amount (Popper et al., 1989). Only 3 percent reported eating more than usual on the first combat day, and 29 percent reported eating the same as usual on the first combat day. Therefore, it is highly likely that underconsumption of rations in a real combat situation would be the same or worse than the underconsumption observed in training exercises.

At this point, the ability to predict the food intake of soldiers depends on both the food (e.g., its packaging, palatability, and form [e.g., liquid]) and the situation (e.g., effort required, timing of the meal, and social factors). By the time one can actually use a performance-enhancing ration in the field, one might be able to control and predict its acceptance and consumption by soldiers, but there is much work in this area that has yet to be done.

PERFORMANCE AND MOOD OUTCOMES

What is the military looking for with regard to performance-enhancing foods? Researchers are interested in what controls human food consumption habits. The military, however, does not have a special need to study what academia can do just as well. Performance-enhancing foods are a subject of interest and investment for the military because it is believed they can enhance militarily relevant behavior. However, the science of soldier performance is not yet mature. At present it is safe to say that researchers do not know what to measure or how to measure it. The measures of physical performance have not changed much over the years, but there is no way to integrate some of those into an overall physical effectiveness score. Measures of cognitive performance have changed, although integrated measurement of cognitive effectiveness is still far off. Combining physical and cognitive scores has probably never been attempted. Variables such as personality and mood must be factored in as well.

A broader issue in performance enhancement measurement is also one of context. Military thinkers involved with soldiers are necessarily thinking in terms of what capabilities soldiers bring to the battlefield. Recently, a newly proposed Army thrust called the Warrior's Edge focuses on enhancement of a soldier's performance in five capabilities: lethality, mobility, command and control, survivability, and sustainment.

Researchers need to begin to think of how to measure these militarily relevant factors and to demonstrate performance enhancement (or decrements) with these measures. A number of measures of lethality pertaining to firing a rifle exist. Similarly, measures of mobility on foot, either marching or on a treadmill, also exist. Command and control deals with the largely cognitive area of communication and information transfer. The greatest problems are survivability and sustainment. For neither of these is there an established measure.

Perhaps most importantly, researchers need to find ways to combine these measures (and perhaps others) to yield measures of overall soldier effectiveness. The USARIEM has begun some modeling work in this area. The ultimate context for performance-enhancing foods for the military will be the field, and measurement of enhanced soldier performance in the field must be the goal.

Assessment of enhanced soldier performance in the field requires that the enhancements provided by nutrient engineering be of sufficient magnitude to be observable and to make a real difference on the battlefield. The literature in this field is filled with caveats about the sizes of effects. Christensen (1991) distinguish chronic nutritional effects that can produce behavioral changes from acute diet manipulations that produce subtle, nonclinical behavioral changes. He suggests that acute manipulations must be done chronically to observe less subtle behavioral effects. They further warn that the psychological context interacts with chronic effects to produce behavioral changes. This means that short-term tests could produce incorrect estimates of behavioral changes—and might even miss them—and that the psychological context might be a necessary component of such demonstrations.

CONCLUSIONS

Consideration of context when planning or interpreting the effects of foods on the behaviors or moods of soldiers will require the following changes:

• Questions will need to be phrased contextually, and investigators will need to plan and conduct their research contextually. This might involve consideration of foods and meals, people issues (individual differences, social influences), environmental issues (both physical and social) and measures of mood and performance.

• In order to consider context, investigators will need to shift their questions in the following direction: Does carbohydrate (when present in *x* form in *y* foods in *z* diets) affect the behavior (e.g., mobility) or mood (e.g., stress) of people (e.g., young males or soldiers of particular selection criteria) over a 3-, 6-, or 12-month period, as compared with a control condition when tested in *x* environment. Then investigators will need to translate those contextual variables into specific test conditions.

• Investigators will need to limit their generalizations of results with the understanding that the phenomena might not extend to other contexts.

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DISCUSSION

DAVID D. SCHNAKENBERG: Herb, I want to compliment you on your thought-provoking paper. You have brought out issues that you and I used to talk about.

I would like to add one point to one study that you cited to me, but I feel it was done by Rose and Carlson (1987) on sustained artillery operations. It was serendipity, the study that was done—7 days of continuous artillery operations with very little sleep to see how the performance of these artillerymen would be degraded. The plan was to feed them MREs [Meals Ready to Eat] three times a day. However, the bugs crawled out of some plant in San Antonio, and the Secretary of the Army put a total moratorium throughout the world that "thou shalt not" eat any more MREs until we find the problem in the production plant.

That happened 2 days before the planned study. There was a question: Should they cancel the study or do something else? They could not feed them MRES. So they took hot meals from the dining hall and carried them out to the field, and the cooks prepared and laid out the food for them. They had to stop the action briefly and let the people sit down and eat the meals and then continue on.

That was the study in which soldiers in the field ate 3,700 calories per day over a 7-day period; they lost no water and did not become dehydrated. Much to the frustration I think of Dr. (James) Vogel, they had no performance decrements.

DAVID D. SCHNAKENBERG: So I think that is one example: If there is nothing physiologically or psychologically wrong with a soldier when he goes outside, if you give him something that he likes to eat and in a situation which gives him time to eat it, he will eat to maintain energy balance. However, these factors are often not all in place in the other field studies that have been undertaken.

ROBERT O. NESHEIM: In every one of the MRE tests that we have evaluated as a committee, we have always had that issue that the troops do not eat enough to maintain their weight. The question is, why don't they? I think the context of the situation is a big part of it.

G. RICHARD JANSEN: That gap you mentioned at the end between, say, the real-world situation and experimental protocols, is a real issue.

HERBERT MEISELMAN: I think the focus groups which Natick has conducted might show you some of the things to look at, but you are going to have to develop something very quantitative after that in order to aid the ration developers, logisticians, and nutritionists..

ROBERT O. NESHEIM: I was reminded, as you were talking, about the problems that I dealt with in a food lab at the Quaker Oats Corporation many, many years ago. We would have very good tests on products that had high degrees of acceptability. They compared very favorably against competitive products, but sometimes you would put them out in a test marketplace and they would fall flat on their face.

It is my understanding that more and more of the food research labs are doing less and less of a detailed product evaluation within the labs, but are doing more and more of it out in the field, simply because they are trying to overcome some of that situation.

JOHANNA DWYER: I just wanted to compliment everybody who made presentations this morning because I thought they were fascinating. I want to revisit this issue of continuity. It seems from David Schnakenberg's statement just now about that experiment where they put the hot foods out, and then from some of the sleep data we heard earlier, this continuity issue seems to be very important.

The question I have is, is it possible to sleep in a tank; is there a way to do it? Similarly, does the context of the combat situation simply preclude this, or are there things that we can consider? What are our constraints as we work the next 2 days with respect to this issue?

JOEL GRINKER: That has been documented by behavioral tests by Dr. Smith in England, and there is no question that there is a decline in intake.

It certainly is important, and it gets complicated in terms of circadian rhythms because the circadian rhythm also has a 12-hour cycle, so that sort of confuses things. That may be part of the cause of that 12-hour cycle.

Also, I think Dr. Bonnie Spring will have some things to say later about the effects of different food on the amount of behavioral change.

I have another comment. I was reminded by the sergeants explaining the importance of eating grasshoppers, about the studies during World War II that addressed food acceptance, in order to get the American public to eat organ meats, they did experiments in which they suggested that if, in fact, they had somebody who posed as an expert—the tests showed—that they got a greater acceptance than if they just told people that this is good for them.

EDWARD HORTON: I am fascinated, as I have listened to this morning's presentation, at the parallelism between sleep deprivation and food deprivation and the importance of the context. If you put a person in a context where he cannot get sleep for very long or you put him in a context where he cannot sit down and enjoy a good hot meal, you end up with these deprivation syndromes. There seems to be a lot of parallelism.

I was wondering if people have looked at the recovery from these. After you have been through a sleep deprivation, do you sleep like a babe after a while? After you have been through a period of food deprivation, do you go back and chow down and make up your energy losses and so forth? Looking at periodic recovery, are there ways to enhance recovery after the fact?

HERBERT MEISELMAN: I think part of our problem is that the more we study this, the more we realize that our tests should be longer and longer in the field. There is a real problem with keeping troops in the field in a training exercise for 4, 6, or 8 weeks and with the associated costs. I think we have thought of what you are suggesting, but it is very difficult to do; it is very long-term testing.

EDWARD HORTON: There are two questions. One is adaptation; adaptations occur over time. The other is recovery and thinking of something like the exercise physiology test where you basically give little rest periods between tests.

HERBERT MEISELMAN: In our first test in 1982, we were positive that the troops would find the diet very monotonous. We predicted that their food acceptance ratings would go down over time, an example of classic monotony.

In fact, what happened is that the troop ratings of the foods stayed absolutely flat for 35 days. But over time they ate less and less and less, so that by the end of the test they were eating considerably less than at the beginning but were not aware of it.

So our simple model of this—that the diet would be monotonous and they would not eat it—did not fit. The diet, in effect, was monotonous if you view it from an intake measure but not from a rating measure.